Long-range Transport of Asian Sulfur Emissions to Canada

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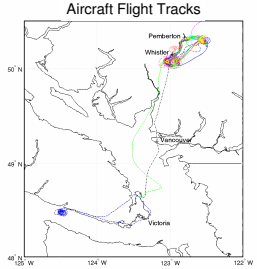
Summary

Agreement between campaign average measurements from satellite and aircraft with modeled values provide confidence in the simulated source appointment of sulfate ($SO_4^=$). Such simulations suggest a significant fraction of ground level sulfate in coastal British Columbia originated in Southeast Asia and that the majority of aerosol optical depth (AOD) observed by satellite during INTEX-B results from $SO_4^=$.

Background

Aircraft Flight Tracks

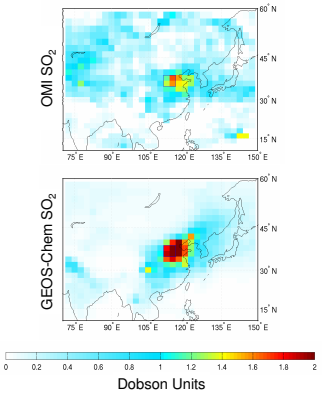


The Canadian Cessna 207 aircraft, operated by Environment Canada, made 33 flights between April 22nd and May 17th, 2006 during the INTEX-B campaign, with flight tracks shown in the adjacent figure. Aerosol instrumentation included measures of ultra-fine aerosol (PMS7610), aerosol size distribution (FSSP300 and PCASP) and aerosol composition, by way of a quadrupole aerosol mass spectrometer (AMS). CO and O3 measurements were also taken. Direct comparison with model data is difficult due to size limitations inherent to AMS data, but not to modeled values. To account for this, we scale AMS measurements using non-speciated size distribution data from the onboard PCASP instrument, assuming aerosol constituents are internally mixed.

We use the GEOS-Chem chemical transport model v7-04-09. Sulfur emissions are based upon the Streets inventory [Streets et al., 2000] scaled to 2006. Scaling to 2003 is based upon CDIAC solid fuel emissions, and continued to 2006 using trends observed with OMI SO_2 [Krotkov et al., 2006]. Total SO_2 emissions from China have increased 275% since 2000.

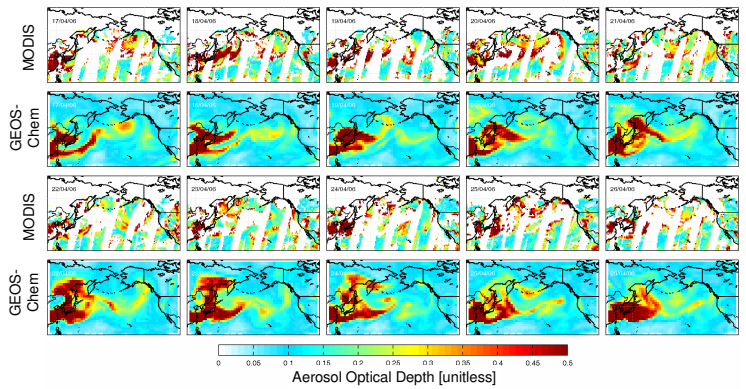
Asian SO_2 Emissions

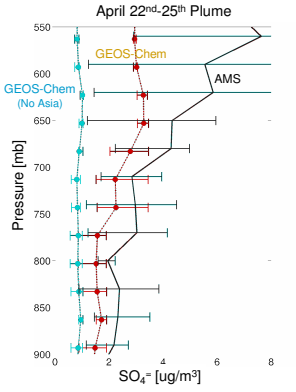
Here we compare Asian SO_2 columns retrieved from the OMI satellite instrument with GEOS-Chem simulations. As shown below, OMI SO_2 columns (top panel) are lower than modeled values (bottom panel) as averaged from May 1st to May 22nd, 2006. This may reflect excessive model emissions or differences in the assumed vertical profile used in OMI SO_2 retrieval.



Influx event Intercomparison

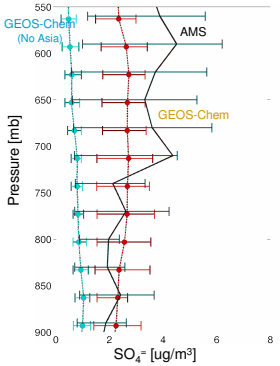
Specific influx events, such as the time series shown below, suggest GEOS-Chem successfully captures the occurrence of daily events. Inter-comparison against Cessna $SO_4^=$ profiles show relative agreement, but with an underestimate in total magnitude between April 22nd and April 25th.

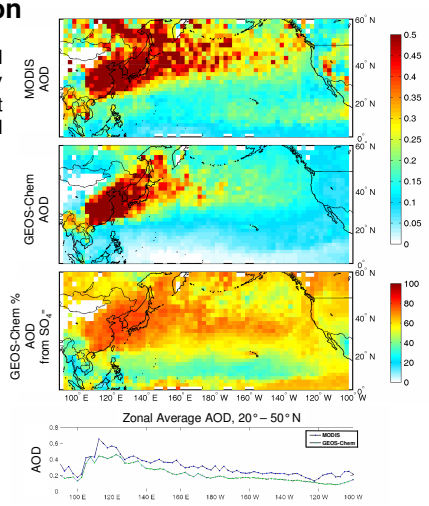


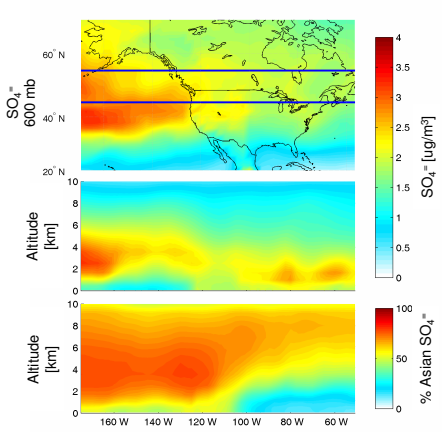


Campaign Average Intercomparison

The top panel shows average MODIS Aerosol Optical Depth (AOD) from April 15th to May 31st, 2006. The middle panel shows coincident AOD modeled using GEOS-Chem. The zonal average at bottom highlights the strong agreement, which is further supported by the campaign average vertical profiles of $SO_4^=$ collected by the Cessna's AMS, shown at left. The AOD observed by MODIS during this time is dominated by $SO4_4^=$.







Effects of Asian Sulfur Emissions

The top panel of the adjacent figure shows modeled sulfate concentrations at 600 mb (~4 km at sea level). The middle panel shows the zonal average vertical distribution, between 45° and 55° N, shown as the blue bands in the top panel. The bottom panel indicates the percent sulfate that is of Southeast-Asian origin. This suggests that during springtime more than half the surface $SO_4^=$ present in British Columbia's southern west coast is the result of long-range transport of Asian sulfur emissions.

Acknowledgement

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References

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